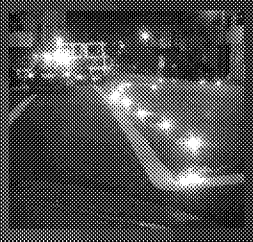
Scale of problem and quick disclaimer

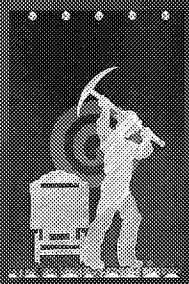
Types of Energetic Materials

- Military Munitions
- Commercial/ Display and Consumer Fireworks
- Marine, Roadside, and Signal Flares
- Automobile Airbag Explosives
- Hobby Rocket Propellants



Users of Energetic Materials

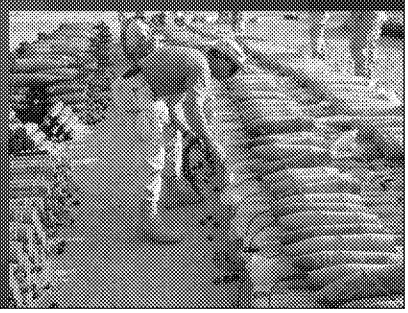
- Government Possession
  - Department of Defense
  - Park Service
  - Law Enforcement
  - NASA
- Private Sector Possession
  - Mining, Demolition, Construction Industries
  - Automobile and Airline Industries



Basic Considerations for Alternatives

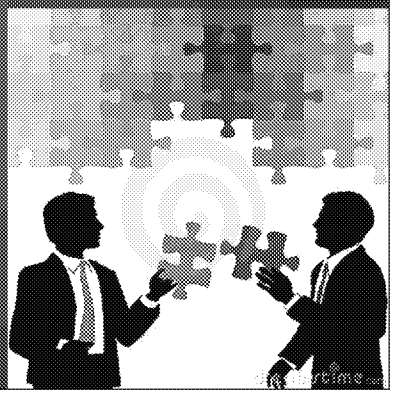
1. Can we produce more environmentally friendly explosive materials?
2. What parts of the explosive ordnances can we reuse/recycle?*
3. How can we dismantle explosive ordnances?*
4. How can we permanently desensitize explosive ordnances?*
5. How can we finish with as close to zero waste as possible?*

*safely→ effectively→ efficiently→ cheaply in the name of preventing a situation like the one that you can see here →



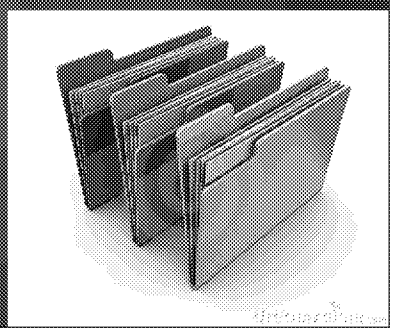
Methods for Identifying Alternative Technology

- Existing Information
- Online Research
- Intra-agency Outreach
- Interagency Outreach
- Industry Outreach



Categorization of Identified Alternative Technology

- Categorization of **initial list** is by basic process properties:
  - Physical
  - Chemical
  - Biological
- Categorization of **final list** is by treatment type:
  - Physical Alteration
  - Chemical Alteration



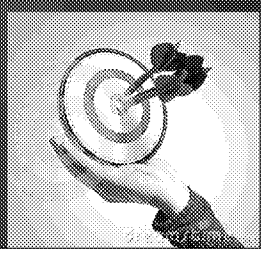
Identified Alternative Technology

- Physical
  - Fluid-jet Cutting
  - Vacuum Infusion
  - Ultrasonic Bath Soaking/Disassembly
  - Injection Soaking
  - Cryogenic
  - Pressure, Heat, and Passive soaking
- Chemical
  - Detonation Chamber/Thermal Treatments
  - Acid Digestion
  - Supercritical Water Soaking
  - Molten Salt Oxidation
  - Electrokinetic Remediation
  - Reverse Osmosis Filtration
  - Nanomaterial
  - Chemical Reduction using Activated Hydrosulfide
- Biological
  - Bioremediation
  - Phytoremediation

Alternative Technology Evaluation Criteria

- Aspects of the treatment technologies were evaluated in the following manner:

1. Safety/Security
2. Environmental Protection (including residuals, reusability, etc.)
3. Compliance with Federal Laws and Policies
4. Effectiveness (including efficiency, throughput, etc.)
5. Cost (cradle to grave)



Final List of Promising Technologies

- Available
  - Fluidjet Cutting
  - Improved Conventional Munition (ICM) R^3
  - Detonation Chambers/Thermal Treatments
  - Conversion to Fertilizer (base hydrolysis with humic acid)
  - Bioremediation
  - Chemical Reduction using Activated Hydrosulfide
- In Testing
  - Nanomaterial Remediation
  - Vacuum Infusion

How might these technologies be used?

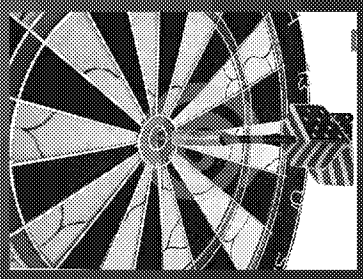
- Either by itself (physical alteration):
  - Improved Conventional Munition (ICM) ?
  - Nanomaterial
- Or in tandem with another technology (chemical alteration):
  - Vacuum Infusion→ Nanomaterial, Bioremediation, Activated Hydrosulfide Chemical Reduction, or Conversion to Fertilizer
  - Fluidjet Cutting→ Nanomaterial, Bioremediation, Activated Hydrosulfide Chemical Reduction, or Conversion to Fertilizer
  - Detonation Chambers→ Nanomaterial, Bioremediation, Activated Hydrosulfide Chemical Reduction or Conversion to Fertilizer

Uses Continued…
Dealing with Transportation Issues

- Mobile Units
  - Varying levels or portability
  - Useful for:
    - Emergencies and
    - On site treatment in limited access locations
- Stationary Units
  - Useful for:
    - Treatments requiring large spaces
    - Continuous waste streams and/or large quantities

When should one be used instead of another?

- To make sure that the right technology is being used, one should take into account:
  - Level of Emergency
  - Type of Explosive Material
  - Scale of Problem
  - Cost



Level of emergency
Area directly around explosive ordnance
Age/level of deterioration of explosive ordnance

Scale of problem
Size of explosive ordnance
Volume of explosive material to be treated

Type of explosive material
Improvised devices vs. military munitions vs. fireworks and other pyrotechnics

Cost
Goes back to scale Municipality/local sheriff vs. large federal agencies

Special Thanks

- The EDAT Team: Ken Shuster, Ben Lesser, Mike Galbraith, Jeff Gaines
- Barry Breen
- Everyone else in the office from whom I learned so much
- Ricky Stauber and Jonathon Sperka
- Dr. Daman Walia
- Dr. Solim S. W. Kwak
- David Heaven
- Dr. Randy Kramer
- Keith Cliff
- My Fellow Interns